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OCR A Level Computer Science

H446 – Paper 1

1

Arrays, tuples and records

Unit 7
Data structures

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Objectives

- Be familiar with the concept of a data structure
- Understand how data is represented and stored within different structures including
    - arrays up to three dimensions
    - tuples
    - records
- Use 1- 2- and 3-dimensional arrays in the design of solutions to simple problems

Variable declarations

- Describe the function of a variable declaration
- Why do we use them?
- Do all languages have explicit variable declarations?

Data structures

- In programming languages there are elementary data types such as char, real, integer and Boolean
- There may be built-in structured data types such as strings, arrays, lists and records
- Structured data types are usually made up of elementary data types
- What is a string made from?
- What would an array of ages look like?

An array of names

- If you need to sort, for example, 100 names of towns into alphabetical order, it is inconvenient to have different names town1, town2, town3 to hold them
- Instead, they are all given one name, and referred to by an index as, for example, town[0], town[1] ...town[n]
  - Note the use of [ ] to hold the index
  - Some programming languages may use ( ) instead

Referencing array elements

Follow the pseudocode and complete the trace table

```
name1 = “Joe”
name2 = “Jim”
name[0] = “Moe”
name[1] = “Mae”
name[2] = “Mic”
for i = 0 to 2
    print (name[i])
next i
print (name1)
print (name2)
```

name						
name1	name2	0	1	2	i	OUTPUT

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    print (name[i])
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print (name2)
```

name						
name1	name2	0	1	2	i	OUTPUT
Joe	Jim	Moe	Mae	Mic	0	Moe
					1	Mae
					2	Mic
						Joe
						Jim

Arrays of numbers

- Arrays can also hold numbers
  - Assume the inputs are: 60, 70, 80
- What does this algorithm do?

```
total = 0
for i = 0 to 2
    mark[i] = input
    total = total + mark[i]
next i
avg = total / 3
print (avg)
print ("3rd mark", mark[2])
```

mark						
0	1	2	i	total	avg	OUTPUT

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mark						
0	1	2	i	total	avg	OUTPUT
				0		
			0			
60				60		

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print ("3rd mark", mark[2])
```

mark						
0	1	2	i	total	avg	OUTPUT
				0		
			0			
60				60		
	70		1	130		

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next i
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print ("3rd mark", mark[2])
```

mark						
0	1	2	i	total	avg	OUTPUT
				0		
			0			
60				60		
	70		1	130		
		80	2	210		

Arrays of numbers

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print ("3rd mark", mark[2])
```

mark						
0	1	2	i	total	avg	OUTPUT
				0		
			0			
60				60		
	70		1	130		
		80	2	210		
					70	

Arrays of numbers

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  - Assume the inputs are: 60, 70, 80
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```

mark						
0	1	2	i	total	avg	OUTPUT
				0		
			0			
60				60		
	70		1	130		
		80	2	210		
					70	
						70
						3rd mark 80

Worksheet 1

- Complete the questions in **Task 1**

2D arrays

- It is also possible to have two-dimensional arrays
- What values would appear in the table once the algorithm has run?

		j	
		0	1
i	0	?	?
	1	?	?

```
array grid[2,2]
for i = 0 to 1
        for j = 0 to 1
            grid[i,j] = "x"
        next j
next i
grid[0,1] = "y"
```

2D arrays

- It is also possible to have two-dimensional arrays
- What values would appear in the table once the algorithm has run?

		j	
		0	1
i	0	x	y
	1	x	x

```
array grid[2,2]
for i = 0 to 1
        for j = 0 to 1
            grid[i,j] = "x"
        next j
next i
grid[0,1] = "y"
```

2D array trace table

- Fill in the trace table if the user inputs

  a, b, c, x, y, z

- Don't forget to fill in i and j

```
array letters[2,3]
for i = 0 to 1
   for j = 0 to 2
      letters[i, j] = input
   next j
next i
```

letters							
[0,0]	[0,1]	[0,2]	[1,0]	[1,1]	[1,2]	i	j

2D array trace table

- Fill in the trace table if the user inputs

  a, b, c, x, y, z

- Don't forget to fill in i and j

```
array letters[2,3]
for i = 0 to 1
   for j = 0 to 2
      letters[i, j] = input
   next j
next i
```

letters							
[0,0]	[0,1]	[0,2]	[1,0]	[1,1]	[1,2]	i	j
						0	
a							0

2D array trace table

- Fill in the trace table if the user inputs

  a, b, c, x, y, z

- Don't forget to fill in i and j

```
array letters[2,3]
for i = 0 to 1
   for j = 0 to 2
      letters[i, j] = input
   next j
next i
```

letters							
[0,0]	[0,1]	[0,2]	[1,0]	[1,1]	[1,2]	i	j
						0	
a							0
	b						1
		c					2

2D array trace table

- Fill in the trace table if the user inputs

  a, b, c, x, y, z

- Don't forget to fill in i and j

```
array letters[2,3]
for i = 0 to 1
   for j = 0 to 2
      letters[i, j] = input
   next j
next i
```

letters							
[0,0]	[0,1]	[0,2]	[1,0]	[1,1]	[1,2]	i	j
						0	
a							0
	b						1
		c					2
						1	
			x				0

2D array trace table

- Fill in the trace table if the user inputs

  a, b, c, x, y, z

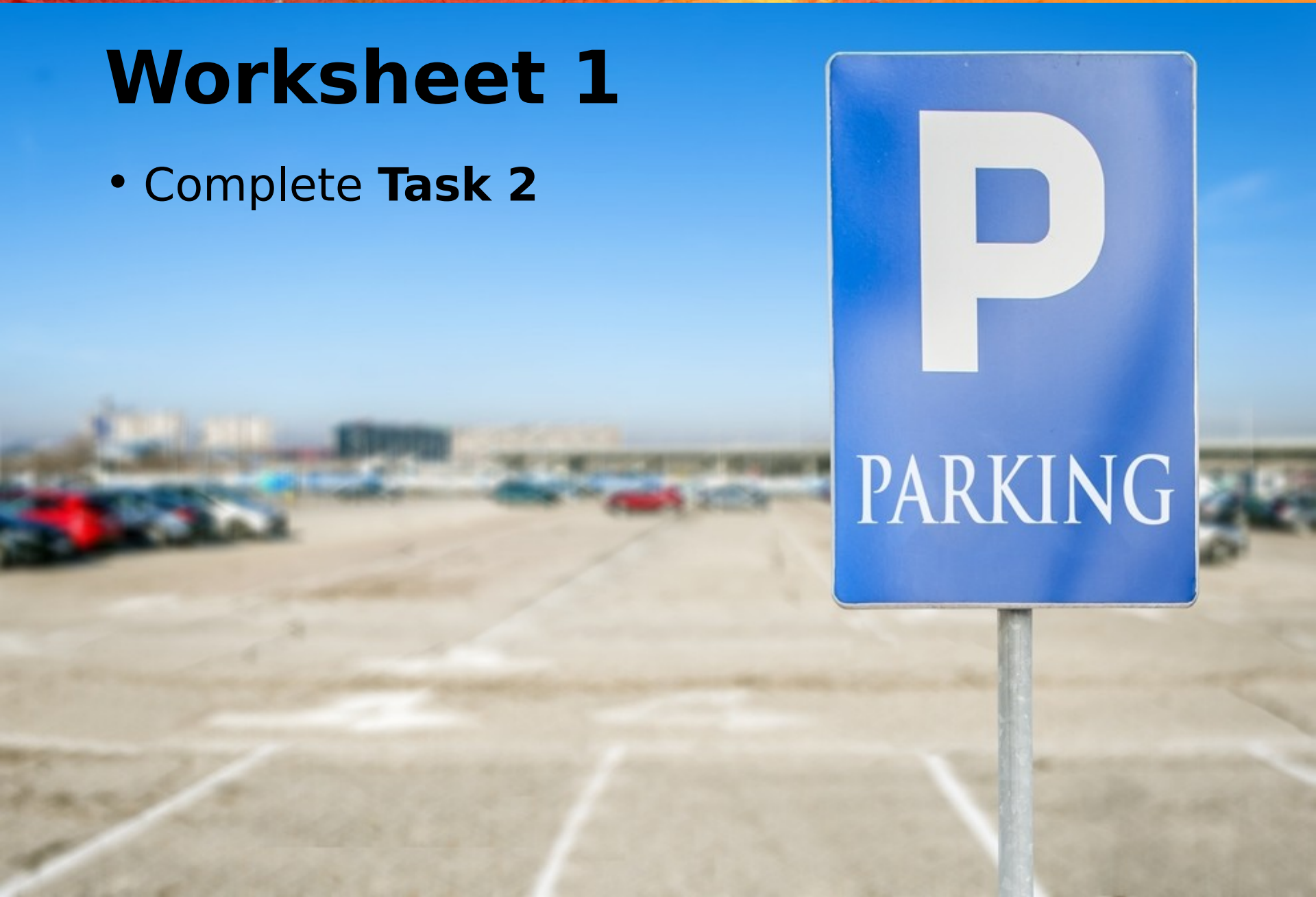
- Don't forget to fill in i and j

```
array letters[2,3]
for i = 0 to 1
   for j = 0 to 2
      letters[i, j] = input
   next j
next i
```

letters							
[0,0]	[0,1]	[0,2]	[1,0]	[1,1]	[1,2]	i	j
						0	
a							0
	b						1
		c					2
						1	
			x				0
				y			1
					z		2

Worksheet 1

- Complete **Task 2**



Multi-dimensional arrays

- It is possible to define arrays with any number of dimensions
- The array is a set of elements with the same data type
  - For example, you could have a 3-dimensional array which would hold x, y and z coordinates in 3-D space
  - You could use a 4-dimensional array to hold sales for branches of a supermarket, by country, store, department, and year
  - e.g. `sales[c, s, d, y]  = 23450`

Tuples

- A tuple has the following properties:
  - It is an ordered set of values
  - It may have elements of mixed types (string, integer, real, Boolean)
  - It is **immutable**, meaning the elements of a tuple cannot change
- Example:
  - Suppose a tuple has elements

    PlayerID, Lastname, Firstname, score1, score2, score3
  - Player1 = (34296, “Jones”, “Jane”, 125, 150, 137)

Tuples

- Tuples can be put together in a 1D array

[1]	(34296, “Jones, “Jane”, 125, 150, 137)
[2]	(115539, “Fox”, “Fred”, 150, 154, 146)

- Why is this data structure not a 2D array?

[1]	(34296, “Jones, “John”, 125, 150, 137)
[2]	(115539, “Fox”, “Fred”, 150, 154, 146)
[3]	(52387, “Smith”, “Sam”)
…	
[n]	(227538, “Zimmer”, Zoe”, 166, 178, 123, 156)

Immutability of tuples

- In the example given:

  PlayerID, Lastname, Firstname, score1, score2, score3

  - Player1 = (34296, “Jones”, “Jane”, 125, 150, 137)
- If Jane’s name has been misspelt, and should be spelt “Jayne”, the tuple cannot be changed
- It is invalid to write, for example,
  - Player1[2] = “Jayne”
- Nor can you cannot add an extra element to a tuple

Records

- Records are composed of a fixed number of fields of different data types
  - Conceptually, they resemble a spreadsheet

ID	Lastname	Firstname	Dept
2468	Jones	John	243
3579	Smith	Sam	634
1428	Zimmer	Zoe	243

Records

- A record can be implemented as an object
- A record can be treated like a tuple
- In writing files, each record is usually written as a single line

ID	Lastname	Firstname	Dept
2468	Jones	John	243
3579	Smith	Sam	634
1428	Zimmer	Zoe	243

Static and Dynamic

- Data structures are characterised according to their ability to grow and shrink on demand
- Dynamic data structures change size when required
  - Lists (arraylists) grow when items are added and shrink when items are removed
- Static data structures cannot change size
  - Arrays in most languages do not change size automatically
  - Some languages provide functions to resize, but this has to be programmed, it is not done automatically

Worksheet 1

- Complete **Task 3**

Plenary

- Complete the table to show the characteristics of these different data structures

	Array	Tuple	Record
Fixed size (static)			
Number of items may grow and shrink			
All items must be of same data type			
Fixed number of items			
Can have 1 or more dimensions			
Items may be of different data types			
Can hold an item of the other two structures			

Plenary

- Complete the table to show the characteristics of these different data structures

	Array	Tuple	Record
Fixed size (static)	✓	✓	
Number of items may grow and shrink			
All items must be of same data type	✓		
Fixed number of items	✓	✓	✓
Can have 1 or more dimensions	✓		
Items may be of different data types		✓	✓
Can hold an item of the other two structures	✓		

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